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Dependence of Edge Turbulence Dynamics and the L-H Power Threshold on Toroidal Rotation[1]

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The injected power required to induce a transition from L-mode to H-mode plasmas is found to depend strongly on the injected neutral beam torque and consequent plasma toroidal rotation. Edge turbulence and flows, measured near the outboard midplane of the plasma ($0.85 < r/a < 1.0$) on DIII-D with the high-sensitivity 2D beam emission spectroscopy (BES) system, likewise vary with rotation and suggest a causative connection. The L-H power threshold in plasmas with the ion ∇B drift away from the X-point decreases from 4-6 MW with co-current beam injection, to 2-3 MW near zero net injected torque, and to <2 MW with counter injection. Plasmas with the ion ∇B drift towards the X-point exhibit a qualitatively similar though less pronounced power threshold dependence on rotation. 2D edge turbulence measurements with BES show an increasing poloidal flow shear as the L-H transition is approached in all conditions. As toroidal rotation is varied from co-current to balanced in L-mode plasmas, the edge turbulence changes from a uni-modal character to a bi-modal structure, with the appearance of a low-frequency (f=10-50 kHz) mode propagating in the electron diamagnetic direction, similar to what is observed as the ion ∇B drift is directed towards the X-point in co-rotating plasmas. At low rotation, the poloidal turbulence flow near the edge reverses prior to the L-H transition, generating a significant poloidal flow shear that exceeds the measured turbulence decorrelation rate. This increased poloidal turbulence velocity shear may facilitate the L-H transition. No such reversal is observed in high rotation plasmas. This reduced power threshold at lower toroidal rotation may benefit inherently low-rotation plasmas such as ITER.

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